

Board Characteristics and R&D Investment: Evidence from Taiwan's Electronics Industry

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Abstract

This study investigates the effects of board characteristics on R&D investment by utilizing a data set of electronics firms listed on the Taiwan Stock Exchange Corporations. The empirical results indicate that R&D investment is negatively associated with board size and positively associated with directors' education level. The impact of board meeting frequency on R&D investment is positive, but not significant. The findings provide one important managerial implication that firms competing on innovation through R&D spending may consider having a smaller board or giving considerable weight to the nomination of highly educated directors to the board.

JEL classification numbers: G31, G34

Keywords: R&D investment, Board size, Directors' educational level, Board meeting frequency

1 Introduction

R&D investment is critical for competitive advantage and long-run success for firms competing on innovation, such as electronics firms [1]. Early investment in R&D may block the success of a competitor's actions, gain market share, alter market dynamics [2] and experience higher firm performance through establishing

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first-mover advantages [3]. Nevertheless, R&D projects are often complicated and demand various resources (e.g., information, knowledge, skills and technology) [4]. Sufficient financial capital and talented personnel are essential to ensure the uninterrupted R&D activities and reduce uncertainty in R&D operations [5] [6].

Numerous previous studies based on resource dependence theory [7] have suggested that boards of directors possessing valuable resources help to reduce environmental uncertainty, and therefore should be exploited when taking important corporate decisions [8] [9] [10]. Reference [3] argues that boards are in a prime position to contribute to the strategic decision making process. Accordingly, this paper seeks to explore the effects of board characteristics (i.e., board size, directors' educational level and board meeting frequency) on R&D investment.

The Taiwanese context is well suited for this study for two major reasons. First, the well-known made-in-Taiwan products are credited to the R&D efforts on the part of Taiwanese firms that tend to focus on applied research [11]. To stay internationally competitive, Taiwanese firms need to continuously focus on R&D. Second, in Taiwan, statutory governance principles have emphasized both the structure and qualification of boards of directors, which should provide a certain pool of potential qualified and talented labor resources.

The empirical findings are based on 227 electronics firms listed on the Taiwan Stock Exchange Corporation. The results provide some support for resource dependence theory by showing that R&D investment is negatively associated with board size and positively associated with directors' education level. The impact of board meeting frequency on R&D investment is positive, but not significant. The findings should extend our knowledge as to how board characteristics shape board functions and effectiveness and consequently investment decisions in R&D.

2 Theory and Hypotheses

According to [12, p. 39], 'how resources are to be allocated around the organization is in the domain of the board', suggesting that a board of directors can directly influence its firm's strategic outcomes. Reference [3] argues that boards are in a prime position to contribute to the strategic decision making process. From a resource dependence perspective, directors helps reduce dependency between the organization and the environment and the related uncertainty for the firm by providing advice to the firm on strategic actions, bringing legitimacy and access to important outside connections, serving as channels of communication between the firm and its outside environment, and aiding in strategy formulation and implementation [10] [13] [14]. Accordingly, this study examines how board directors affect R&D investment by focusing on their characteristics, including board size, directors' educational background and board meeting frequency.

2.1 Board Size

Board size can determine a board's potential to provide a firm with the needed resources. Having more directors increase a pool of expertise, information and advice that a firm can draw on [10] [15]. Additionally, larger boards are assumed to associate with higher levels of links to the external environment, and therefore are more likely to tap into significant resources, improving a firm's access to various resources [16]. Accordingly, larger boards may enhance firms' ability to deal with environmental uncertainty and to establish links with business partners [7], and these help to avert threats to its stability or existence [17].

To effectively implement R&D activities, firms demand knowledge, skills and resources from experts and teams in diverse functions. Larger boards with a greater depth of intellectual knowledge and valuable resources [15] [16] help firms to effectively cope with high information-processing demands, better understand complex environments and develop more holistic alternative solutions [17], consequently improving the quality of strategic investment decision in R&D. Therefore:

H1a: Board size is positively related to the level of R&D investment.

An alternative view suggests that enlarging the board may impede the board's effectiveness in strategic decision making. Although having more directors bring together various knowledge and resources, diverse perspectives of larger boards lead to conflicts among directors that produce distrust and hostility [18]. Additionally, larger boards have difficulties meeting frequently, and therefore are less effective to coordinate the divergent perspectives [17]. The conflicts, unhealthy dialogue and coordination problems [19] increase the difficulty of reaching a consensus on critical decisions, thus limiting a board's ability to direct important strategic decisions [15].

The potential group dynamic problems associated with larger boards may be exacerbated in R&D investment. Reference [15] argues that as complexity and ambiguity increase, larger boards may become factionalized into special interests rather than the goals of the collective group. Since the initiation of R&D projects in a timely manner is very critical, and R&D activities often involve highly complicated and ambiguous tasks, the poor quality of internal dynamics associated with larger boards may hinder the speedy action in R&D investment. Therefore:

H1b: Board size is negatively related to the level of R&D investment.

2.2 Directors' Educational Level

Directors' educational level may determine their skills and knowledge level [20]. Higher levels of education are characterized by greater cognitive complexity [21], leading to a better ability to grasp new ideas [22], learn new behaviors, define issues and find creative solutions to complicated problems [23].

R&D projects are often complicated and ambiguous. Directors with greater educational level may be more receptive to innovation and tolerant for ambiguity [20]. Additionally, advanced education may equip directors with skills that facilitate assessment of research project and provide them with knowledge related to innovation management [24]. Moreover, directors with advanced education may be more capable to absorb new technology [25], acquire requisite knowledge, process and analyze information accurately [26] and develop insights in methods when resolving complicated R&D problems [27]. Accordingly, firms with more highly educated directors would have a deeper understanding of R&D processes and outside environments and thereby are likely better equipped to implement R&D activities, consequently increasing their willingness to invest more in R&D. Therefore:

H2: Directors' educational level is positively related to the level of R&D investment.

2.3 Board Meeting Frequency

Greater frequency of meetings enables directors to devote more time and efforts on firm strategy and business operation by sharing their experience, knowledge and judgment and providing more critical information and valuable resources [28] to advise the management team on significant issues facing the firm and review and assist in major strategic actions [10]. Reference [29] suggests that the greater frequency of meetings is likely to increase the board's effectiveness. Reference [30] argues that greater frequency of board meetings is likely to result in improved governance performance.

In light of the above arguments and research, the increasing complexity of industries and organizations, such as firms competing on innovation, may need to call for frequent board meetings [31]. Frequent board meeting may allow board members to have a better understanding of R&D activities, facilitate the evaluation of innovative projects and provide more opportunities for board members to confer, to set strategy and to manage the operational complexity of R&D [27]. Additionally, frequent board meeting can be valuable for building and developing the network of relationship among board members [32]. The network directorate's ties to other organizations and interlocking directorates may facilitate the access to requisite resources (i.e., financial capital, technology, information and talented personnel) and thus reduce R&D risks resulting from a shortage of resources [4]. Accordingly, meetings may help handle complexities, develop strategic alternatives and reduce uncertainties, consequently leading to a greater likelihood of successful innovative activities [27], which in turn increase a firm's willingness to invest more in R&D. Therefore:

H3: Board meeting frequency is positively related to the level of R&D investment.

3 Empirical Setting

3.1 Sample

This study focuses on the electronics industry during the period 2007–2010 to examine the effect of board characteristics on R&D investment. The electronics industry is chosen because of its dependence on R&D for competitive advantage and long-run success [1]. The financial data (including R&D expenditures, total sales, number of employees, debt ratio and return on equity), board size and institutional stock ownership of the study sample are taken from the Taiwan Economic Journal (TEJ) Data Bank. Data on directors' educational level and board meeting frequency are manually drawn from company annual reports.

3.2 Variables

The R&D ratio, calculated by dividing R&D expenditures by total sales, serves as the dependent variable in the analysis because it is a widely used measure [33] [34].

Board size, directors' educational level and board meeting frequency are three proxies for board characteristics and serve as the independent variables in the study. Board size is the number of directors on the board of an individual company [17]. Following a method used by [22], directors' education Level is measured on a seven-point scale reflecting the highest level of education attained (1 = elementary school, 2 = junior high school, 3 = high school, 4 = two-year college, 5 = four-year university, 6 = master degree, 7 = Ph.D. degree). Board meeting frequency is measured by the frequency of board meetings [16].

To control for firm and ownership effects on R&D investment, this study includes a series of control variables, including firm size, firm performance, debt ratio and institutional stock ownership. The number of employees, logged to correct for skewness, are included as a measure of firm size [24]. Firm performance is measured through return on equity [4]. Debt Ratio is measured as the ratio of the book value of total debt to the market value of the equity and book value of debt [4]. Institutional stock ownership is the ratio of shares held by institutions to total shares outstanding [22].

3.3 Methodology

This study uses hierarchical ordinary least square (OLS) regression to test the hypotheses. Following reference [24], this study uses an average value of each variable to reduce the possibility of an extraordinary value in one particular year biasing the empirical results. Additionally, to mitigate potential endogeneity [35], ensure that the direction of causality is from board characteristics to R&D

investment and not the reverse [36], and allow ownership and governance features time to reveal their impacts on strategic choices, the dependent variables (from 2008-2010) are regressed against independent and control variables (from 2007-2009).

4 Empirical Results

Table 1 presents the descriptive statistics and correlation matrix. On average, the R&D ratio is 5.07%. The companies in the sample have board size of about 6~7 members. The mean level of education attained by the sample boards of directors is somewhere between having an undergraduate and a master's degree. The sample firms held about 9~10 meetings in the financial year. The matrix shows the modest correlations between independent variables, suggesting that multicollinearity problems are unlikely. To further test for multicollinearity, the variance inflation factors (VIFs) are calculated for each independent variable. The VIFs of 1.1-1.5 are strictly less than 2, suggesting that the regression models are relatively free from potential multicollinearity problems.

Table 1: Means, Standard Deviations and Correlations

Variables	Mean	S. D.	1	2	3	4	5	6	7
1. R&D Ratio (%)	5.07	5.81	--						
2. Board Size	6.82	1.79	-0.18**	--					
3. Directors' Educational Level	5.37	0.62	0.16**	0.11*	--				
4. Board Meeting Frequency	9.62	3.73	-0.04	-0.05	-0.17**	--			
5. Firm Size (log)	2.72	0.58	-0.06	0.34***	0.16**	0.20**	--		
6. Debt Ratio (%)	34.08	14.71	-0.37***	-0.05	0.11*	0.08	0.11*	--	
7. Firm Performance (%)	4.26	33.45	-0.12*	0.04	-0.11*	0.11*	0.20**	-0.22***	--
8. Institutional Ownership (%)	35.93	20.69	-0.07	0.23***	0.17**	0.13*	0.44***	0.04***	0.09

Table 2 summarizes the lagged hierarchical regression analysis. Model 1 includes the control variables (institutional ownership, debt ratio, firm size and firm performance) and shows that the control variables explain 16.74 percent of the variance in R&D ratio. Model 2 ~ Model 5 include the hypothesized effects of board characteristics (board size, directors' educational level and board meeting frequency) in addition to the control variables. Specifically, Model 2 shows that R&D ratio is negatively and significantly related to board size, supporting Hypothesis 1b. Model 3 shows that R&D ratio is positively and significantly related to directors' educational level, supporting Hypothesis 3. Model 4 indicates a positive, but not significant, relationship between board meeting frequency and R&D investment. Finally, the results of Model 5 show that the findings are qualitatively identical if the three independent variables are added at once.

Table 2: Results of regression analysis

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
Intercept	9.89 ^{***} (5.47)	13.10 ^{***} (6.66)	1.29 (0.39)	9.80 ^{***} (5.16)	3.58 (1.03)
Control Variables					
Firm Performance	-0.04 ^{**} (-3.38)	-0.04 ^{**} (-3.67)	-0.03 ^{**} (-3.01)	-0.04 ^{**} (-3.37)	-0.04 ^{**} (-3.30)
Firm Size	0.58 ^{***} (-6.05)	1.33 (1.89)	0.35 (0.51)	0.56 (0.80)	1.07 ^{***} (1.52)
Debt	-0.17 ^{***} (-6.70)	-0.18 ^{***} (-7.23)	-0.17 ^{***} (-7.01)	-0.17 ^{***} (-6.67)	-0.18 ^{***} (-7.62)
Institutional Ownership	-0.02 (-0.80)	-0.01 (-0.51)	-0.02 (-1.18)	-0.02 (-0.81)	-0.02 (-0.93)
Main Effects					
Board Size		-0.75 ^{**} (-3.65)			-0.78 ^{**} (-3.85)
Directors' Educational Level			1.79 ^{**} (3.12)		1.97 ^{**} (3.44)
Board Meeting Frequency				0.01 (0.15)	0.04 (0.40)
Adjusted R ² (in %)	16.74	21.13	19.89	16.37	24.52
Change in Adjusted R ² (in %)	N/A	4.39	3.15	-0.37	7.78
F-statistics	12.36 ^{***}	13.11 ^{***}	12.22 ^{***}	9.85 ^{***}	11.49 ^{***}

Notes: ***, **, *stand for significance within respectively the 0.1%, 1% and 5% level. Numbers in parentheses are t-statistics. The change in adjusted R² of Model 2, 3, 4 and 5 is relative to the Model 1. Number of observations = 227.

5 Conclusion

This study examines the effects of board characteristics on R&D investment and its empirical results provide some support for resource dependence theory by showing that R&D investment is negatively associated with board size and positively associated with directors' education level. The impact of board meeting frequency on R&D investment is positive, but not significant.

Research on corporate governance has invariably focused on developed economies, and limited research exists on the extent to which the corporate governance issues of developed economies are applicable to emerging economies [16]. The use of Taiwanese data to investigate the board influence on R&D

investment can shed light on the governance–R&D relationship within the context of emerging economies [30]. The findings of this study should extend our knowledge as to how board characteristics shape board functions and effectiveness and consequently affect corporate investment decisions, such as R&D.

The empirical results suggest that firms having smaller boards and having more highly educated directors in the board tend to invest more in R&D, thus making the following managerial implication. The findings of a negative/positive relationship between board size/directors' educational level and R&D investment suggest that firms wanting to strengthen their innovation strategy may consider having a smaller board or giving considerable weight to the nomination of more highly educated directors to the board.

This paper has limitations and thereby provides opportunities for further research. Data are collected exclusively in Taiwan, introducing a potential bias regarding the relationships between board characteristics and R&D investment and thereby limiting the possibility to generalize the findings to other countries. Additionally, the findings are limited to the electronics industry. A future comparative country- or industry-wide study is recommended.

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